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GENERAL INFORMATION

Title: Doctorate in Earth and Environmental Sciences

Coordinator: Prof. Roberto Sacchi

Doctoral Project title:

Construction of a 3D model of the Po Plain subsoil for the protection of groundwater and its sustainable exploitation by low-enthalpy geothermal energy.

University tutor: Di Giulio Andrea

Company tutor (Eni): Marco Meda

Company tutor (CAP): Chiara Righetti

A. PROPOSED RESEARCH

1- Theme of the research, highlighting its coherence with Green or Innovation themes (max 3000 characters):

The energy scenario of the next decades and the impact that ongoing climate change is having and will have on the availability of water resources are issues that are closely intertwined in many areas. One of these areas is the Po Valley (Northern Italy), a place where population density, quantity and strategic importance of infrastructure and agricultural and industrial activities are particularly high.

The character of an alluvial plain with important thickness of sediments and buried geological structures make the Po Valley an area rich in underground water and mineral resources, which have been intensively exploited since the post-war period. This activity provides a largely overlooked amount of subsurface data that can be explored to face the new challenges of the modern society.

The proposed PHD program aims at reconstructing a basin-scale 3D model of the stratigraphic architecture of the uppermost part of the Po Valley subsurface (with particular reference to the central-western Po Valley) through the integration of geophysical data and well stratigraphy. The 3D geological model should focus on the reconstruction of the main Pliocene-Pleistocene stratigraphic discontinuities, on the characterization of the sediment packages included between these surfaces and on the mapping of the brackish water-fresh

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water interface at depth. Being able to know the geometry and the dynamics of the brackish water-fresh water interface by associating temperature and water conductivity measurements would allow to know a fundamental hydrogeological element for a correct and effective exploitation of water resources and at the same time provide valuable data to evaluate potential of deepest aquifers of the Po Valley from the point of view of their use for low-enthalpy geothermal purposes.

A basin-wide study of this possible use of a renewable and clean resource and of the possible impacts that ongoing climate change could have on it is clearly in line with the objectives of reducing climate-impacting emissions and increasing renewable energies and would also be of potential economic interest for several productive sectors in the country, starting with the companies working on water service management and energy companies involved in the energy transition.

In this perspective, the proposal can count on the availability of CAP Holding, leader in the water service management in Lombardy, and a collaboration with Eni, owner of the most of stratigraphic and geophysical data of the Po Valley subsurface; it is believed that this high-level corporate support represents an important added value of the proposed project.

2- Proposed research activity, methodologies and contents (max 3000 characters):

The planned research activities can be summarized in the following points:

- Analysis of the existing bibliography and any public subsurface data on the case study area.
- Retrieval of available subsurface data (stratigraphy of water and hydrocarbon wells, seismic reflection, chemistry and temperature of groundwater) from Eni and various public databases (e.g. VIDEPI, local authorities, operators in the fields of integrated water service etc.).
- 3D reconstruction of the architecture of the geological context in which the investigated basin is inserted.
- 3D reconstruction of the stratigraphic-sedimentologic architecture and petrophysical characteristics of the intervals investigated .
- Construction of geological cross-section and structure contour maps of surfaces (e.g. Pliocene base, top and base of deep aquifers, freshwater-saline water boundary) based on available data.



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- Estimation of the volumes of water potentially present in the different stratigraphic intervals at different depths and evaluation of the possible medium-term effects of climate change on them.
- Insertion in this basin-scale context of sample areas in which the available data allow the construction of detailed hydrogeological models based on dedicated softwares.

3- Degree of innovation of the proposed research in the field of intervention (max 3000 characters)

The protection and proper exploitation of water (especially deep water) in an area with high density of population and agricultural and industrial activities, some of which have a high impact and require huge amount of water, is certainly one of the major national challenges of the near future.

From this point of view, the Po Valley, and its Lombardy and Piedmont portions are certainly a national priority. Nevertheless, to date there is no coherent and unitary model at basin scale of the shallowest part of the Po Valley subsoil that should represent the necessary physical framework of every detailed hydrogeological model that various operators in the underground water management are progressively producing.

The proposed project aims to provide this framework by implementing important and so far missing data at regional scale, such as for instance the current depth of fresh-saline water boundary in the subsoil and information on the temperature of these waters.

The contribution provided by two leaders in the field of water service management (CAP) and energy (Eni) guarantee to the project a great transferability of results and a great training potential for the enrolled PhD student.

4.- Consistency of the research topic with the disciplinary field of the PhD and with the composition of the Board of the doctorate school (max 3000 characters):

The board of professors of the PhD program in Earth and Environmental Sciences includes professors and researchers with expertise fully consistent with the topic of the proposed research. In particular, the presence of Structural Geologists and Sedimentologists allows the board to fully guide and evaluate the activities of the PhD student from the point of view of the reconstruction of the subsurface geological model and of the petrophysical



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characters of the investigated stratigraphic intervals. The multidisciplinary composition of the Academic Board, where there are also professors of Engineering Geology, Geomorphology, Natural Sciences, would also allow to support and integrate the proposed research activities with skills (geological and biological) certainly important for a proper and full assessment of the environmental impact of possible developments in terms of exploitation of deep water resources both for drinking and low-enthalpy geothermal purposes.

5 – Technical feasibility of the proposal and implementation schedule (max 3000 characters):

The Department of Earth and Environmental Sciences and the company partners are able to collect, organize and process the data necessary for the research by virtue of many years of joint research experience (both on completed and ongoing projects). The companion partners identified for the research have skills, tools and experience in different fields but that can be well integrated in the exploration of the subsurface and in the reconstruction of geological models. Several software used for modelling are common and also the physical proximity between the partners' offices make technically and logically simple and fast the exchange of data or visits at different sites.

An outline timetable of the activities is outlined below, but consider that several of the proposed activities may partially overlap in time.

Year 1 (months 1-4): Analysis of existing bibliography and public subsurface data on the portion of the plain to be studied and possible request for additional data from agencies, consortia and individuals.

Year 1 (months 5-8): Integration of public and subsequently requested data and interpretation of reflection seismic data.

Year 1 (months 9-12) realization of subsurface geological model related to the Plio-Pleistocene stratigraphic interval.

Year 2 (months 1-4): reconstruction over the entire study area of the freshwater-saltwater interface in the subsurface.

Year 2 (months 5-8): collection and analysis of well data for a hydrogeological characterization of the study area.

Year 2 (months 9-12): collection and analysis of hydrogeological, geochemical and temperature data for the reconstruction of the dynamics of saline or positive thermal anomaly flows.



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Year 3 (months 1-4): integration of the data into a final hydrogeological model that includes: i) the geometry of the main Pliocene-Pleistocene unconformities in the study area; ii) the general and detailed hydrogeological setting of the first subsurface; and iii) the saltwater-freshwater interface.

Year 3 (months 5-7): estimation of fluid volumes hosted by the reconstructed geologic setting and flow dynamics related to differences in groundwater density and temperature.

Year 3 (months 9-12): synthesis of results + writing of PhD thesis.

6 – Synergies with respect to the possible subsequent employment of the PhDs (in relation to the world of work) (max 3000 characters):

The candidate who will undertake the research will have the opportunity to work closely with different teams of corporate work, on an innovative topic with potentially strong commercial interest by multi-utility companies such as those partners in this research, make the project particularly promising for a potential subsequent inclusion of the student in the companies involved, or in others in the same sector.

Being able to identify, albeit at a basin scale, the base area of the resource (water) exploited by the company and measure chemical and physical parameters of water that may indicate a potential for low-enthalpy geothermal energy is a topic that could open up opportunities for sustainable exploitation of groundwater and all this will require specifically trained resources.

B. ACTIVITIES TO BE CARRIED OUT AT THE COMPANIES' premises throughout Italy

1 – Research activities to be carried out at the companies (max 3000 characters):

The research activities to be carried out at the companies include the analysis of hydrogeological data and the realization of detailed hydrogeological models on portions of the study area where the abundance of data allows it. These activities will be carried out probably during the second year of the PhD; however, periods of work at the host companies will be necessary also during the third year for the necessary control activities



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and validation of the hydrogeological model. It is therefore expected an extended period (3-4 months) of stay in each involved company in the initial stages of research and shorter periods (approximately 1 month) for the subsequent and final activities.

2 – Name of the companies where the activity related to the research topic will be carried out

Eni SpA e Gruppo CAP

3 – Registered office of the companies (City, Province, address)

Eni SpA - Sede Legale, Piazzale Enrico Mattei, 1- 00144 Roma – Italia

GRUPPO CAP - Sede Legale Via Rimini 38 - 20142 Milano

4 – Principal place of work (and if relevant organizational unit) where the research activity of the doctoral candidate will be carried out

Eni S.p.A. - Exploration and Production Division, Via Emilia 1 - 20097 San Donato Milanese (MI) – Italy

Centro Ricerche CAP - Idroscalo - Ingresso Riviera Est, Via Circonvallazione Est, Segrate 20090 (MI)

5 – Name, surname and e-mail of the company tutors

Dr.sa Chiara Righetti (Responsabile Modelling idrogeologico CAP)
chiara.righetti@gruppocap.it

Dr. Marco Meda (*MGR GEOLOGY & GEOPHYSICS RESEARCH & TECHNOLOGICAL INNOVATION*) marco.med@eni.com

6 – Method of tutoring supervision of doctoral students (max 1000 charaters)

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When the doctoral program will begin, an initial briefing will be scheduled in the first weeks for detailed planning of the work (doctoral student+university tutor+company tutor). During the activities at the University the doctoral student will have the opportunity to work daily in contact with the university tutor and other members of the teaching staff with the necessary skills to assist and guide him/her.

Periodic meetings will be scheduled between doctoral student and university tutor and meetings (possibly also online) with the company tutors individually or when appropriate jointly.

During the stay at the companies the doctoral student will work in work teams collaborating with the various technical specialists active in the units where he/she will be hosted.

For the supervision of the progress of work with respect to the schedule will be held monthly meetings (doctoral student + tutor company + university tutor) while the partial results will be verified every 4 months possibly identifying a small panel of external researchers, experts in the field, which can provide insights and identify any weaknesses in the training and research.

7 - Durata di permanenza in impresa del dottorando titolare della borsa aggiuntiva (minimo 6 mesi, massimo 12)

6 months in each company for a total of 12 months

8 – Use of the results and outcomes of the research activity for the enhancement of the skills of the doctoral student with reference to the field of intervention (max 3000 characters)

During the period of study the PhD student will acquire multidisciplinary skills in the field of three-dimensional reconstruction of complex geological bodies and in the field of homogenization and treatment of data from different sectors (oil and gas exploration and hydrogeology). The evaluation of the possible exploitation of water resources for drinking water and / or geothermal low enthalpy will complete the training and experience of the student who will then present to the world of work with a wealth of experience and multidisciplinary skills highly expendable in the field of sustainability and energy transition as well as the protection of resources from depletion and pollution risk.



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C. ACTIVITIES ABROAD (if deemed necessary for the purpose of the project)

1 – Research activities to be carried out abroad (max 3000 characters):

Not currently planned

D. ATTIVITA' FORMATIVA PRESSO L'UNIVERSITA'

1 – Procedures and content of additional training activities for doctoral students (in addition to those already provided by the doctoral program) relevant to the path identified (max 3000 characters)

In addition to the training paths provided by the Doctoral School in Earth and Environmental Sciences of the University of Pavia, the PhD student will attend courses and conference sessions specific to his training.

In the initial phase of the PhD, it is expected that the candidate will attend courses related to the calculation and modelling tools at the software houses that develop these computer tools, mostly already in possession of both UNIPV and the company partner.

Finally, it is foreseen to encourage the participation of the PhD student to symposia, seminars or short courses specifically dedicated to the sustainable exploitation of water resources as well as on the possibilities of exploitation of aquifers in flood plains for geothermal purposes.

2 – Elements of co-design or direct intervention by the companies (max 3000 characters)

The research activities of this project have been developed in close collaboration between the Academy and industrial partners and respond to the medium-term needs (research and professional) of the proponents. It is also the intention of the proponents (university tutor + business partners) to use the knowledge and results derived from this research to collaborate, even after the end of the PhD, to submit proposals and research projects both national and European, taking advantage of the network of contacts and knowledge, even in the international arena, which will result from the collaboration that will develop during this research (for example on LIFE calls that between 2021 and 2027 will be funded with 5.4 billion euro on issues such as climate change mitigation and adaptation and clean energy transition).



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3 – Degree of compliance of the proposal with the demand for higher education to ensure the appropriate skills required by the productive fabric in relation to Green and Innovation (max 3000 characters)

The training and research pathway foreseen in this PhD program responds to the need to train highly educated professionals who combine specialized and multidisciplinary skills. The objective is in fact to prepare specialists who can not only produce three-dimensional models of geological or hydrogeological bodies, but can also assess the potential in terms of sustainable exploitation and the medium-term effects that global climate change may induce.

E. CONTRIBUTO AL PERSEGUIMENTO DEI PRINCIPI ORIZZONTALI

1 – Initiatives put in place to ensure the principles of equal opportunity, anti-discrimination, gender equality and accessibility for people with disabilities both in access and in the implementation of the doctoral program (max 3000 characters)

The doctoral programs activated by the University of Pavia promote equity and the protection of men, women and transgender people and all categories of people and groups from any kind of unequal treatment and/or discrimination. The candidate will be encouraged to participate in events organized by organizations and scientific groups that ensure inclusive and non-discriminatory policies and conduct. The University of Pavia periodically organizes meetings for discussions and training moments dedicated to the fight against discrimination and the Teaching Board of the PhD program in Earth and Environmental Sciences promotes the participation of PhD students to conference sessions on specific topics such as gender equity and inclusiveness.

2 – Presence of environmentally friendly solutions in the implementation and management of doctoral program, including for example the presence of specific module or training content in the field of Green and/or innovation (max 3000 characters)

Travel by public transportation, especially train, will be promoted and encouraged. In full respect of the research and training program and of the work periods foreseen in the companies, it is foreseen to hold the most technical meetings using the online mode. The



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fact that the university and the companies own and use the same software tools allows a perfect communication and an effective and quick data exchange without frequent movements.

During the doctoral student's training, he or she will be encouraged to attend cycles of seminars or courses dedicated to green issues.

Courses already activated at the University of Pavia that deal with "green" issues and useful to provide knowledge that integrate and complement those strictly geological PhD students will be included in the three-year training path. As an example the courses already present at UNIPV could be "Energy scenarios", "Sustainability and resource management" and "Human progress and sustainable development".